(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 123 221 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.01.2023 Bulletin 2023/04

(21) Application number: **21187117.3**

(22) Date of filing: **22.07.2021**

(51) International Patent Classification (IPC):
F23D 14/02 *(2006.01)* ***F23D 14/70*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F23D 14/02; F23D 14/70; F23C 2900/9901; F23D 2203/1012; F23D 2203/102; F23D 2210/00; F23D 2900/00003

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **BDR Thermea Group B.V.**
7332 BD Apeldoorn (NL)

(72) Inventors:
- **KAPUCU, Mehmet**
7332 Apeldoorn (NL)
- **RUTGERS, Job**
7332 Apeldoorn (NL)

(74) Representative: **Dennemeyer & Associates S.A.**
Postfach 70 04 25
81304 München (DE)

(54) **GAS BURNER WITH A VOLUME REDUCER**

(57) Volume reducer (1) for a gas boiler (2), in particular a hydrogen boiler, placeable inside a burner chamber (3) of a burner (4), the volume reducer (1) comprising a wall (6) that protrudes into the burner chamber (3) when the volume reducer (1) is placed in the burner (4), wherein the wall (6) is configured such that a gas mixture (15) flowing into the burner (4) is prevented from passing through the wall (6) protruding into the burner chamber (3).

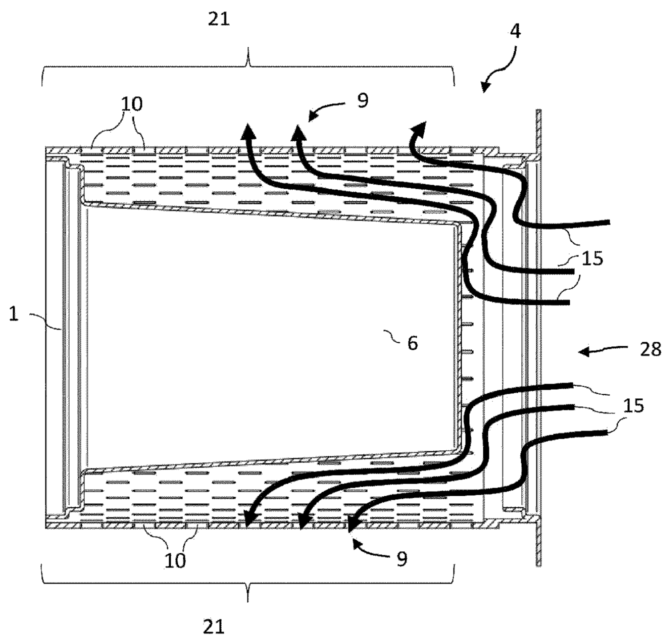

Fig. 2

EP 4 123 221 A1

Description

[0001] The invention relates to a volume reducer for a gas boiler, in particular a hydrogen boiler and to a burner comprising said volume reducer. Additionally, the invention relates to a combustion appliance comprising the volume reducer or the above-mentioned burner. Also, the invention relates to the use of the volume reducer or the burner for reducing the space where a gas mixture flows inside a burner chamber and to a method for retrofitting a combustion appliance.

[0002] Gas boilers combust gas fuel to heat water for domestic use and/or central heating systems in buildings. Usually, a central heating water circuit is heated, as well as a hot water supply. Due to the presence of high flammable gases in the combustion circuits and systems, conditions for an explosion can occur. Furthermore the type of combustible gas can even increase this risk. For example, compared to methane or natural gas, hydrogen has higher flammability (4%-75% for H_2 compared to 5%-17% for natural gas). Therefore, in case of explosion of a gas boiler using pure hydrogen as fuel gas, the damages could be more severe compared to cases where other fuel gases are used. In addition, the use of hydrogen can lead to further problems. For example, hydrogen is more prone to flashback due to a higher flame speed compared to natural gas (i.e. increase of about 500%). Flashback is also increased by an unequal distribution of the gas mixture over the burner ports.

[0003] It is therefore desirable to reduce the drawbacks in using hydrogen as fuel gas. It is particularly desirable to reduce damages during a possible explosion and to reduce the risk of flashback when hydrogen is used as fuel in a gas boiler.

[0004] US 6,139,312 is directed to providing a burner with a flame distributed along the circumference and which allows free expansion of the circumference, maintaining the volume and speed of the mixture which exits the apertures at the most suitable values for optimum combustion, in terms of both the efficiency of the combustion and uniform distribution of the flame along the burner and discloses a gas burner comprising an elongated tubular body with a sidewall which has outer end edges between which there are apertures which pass through the sidewall, and a flange with a central through hole and an opposite base cap, the sidewall, flange and base cap being attached to one another in such a way that together they define a first mixing chamber, in which a flow of gas and air, received through the flange, exits the tubular body through the apertures in the sidewall. The flange and base cap have opposite guides and the sidewall is wound in a spiral and has juxtaposed longitudinal edges with fluid tight seals and outer end edges inserted in the guides with a play designed to allow the perimeter of the sidewall to expand or contract according to changes in the temperature of the body. This configuration shows a structure in the burner having an open surface that is only suitable for the distribution of a gaseous fluid.

[0005] US 20200049345 A1 is directed to providing a burner with a support plate formed in one piece with the diffuser connection flange, in particular of aluminum, and a method for manufacturing the burner, having such features to allow a fast, precise and cost-effective junction between the support plate and the diffuser and/or further flow elements, e.g. a distributor and discloses a gas burner comprising a support plate with a passage opening for the gas and an annular wall formed around the passage opening, a diffusing wall and a further flow element inserted on the annular wall in flow communication with the passage opening. The annular wall forms a plurality of punches with a recess and an opposite projection, wherein the recess accommodates a locking protuberance of the diffusing wall and the projection extends in a locking hole of the further flow element. The structure in the burner has an open surface and only increases mixing length and enhances flow distribution.

[0006] EP 1 221 571 B1 is directed to providing a combustion device which offers the designer of the combustion device a greater degree of technical freedom in order to coordinate the above-mentioned requirements which are placed on a combustion device in a more optimal manner and discloses a combustion device for burning a mixture of gas and air comprising a burner with two ends positioned in a combustion chamber, a mixing device for mixing the gas and air, a first feed channel for feeding the gas to the mixing device, a second feed channel for feeding the air to the mixing device, and a third feed channel for feeding the mixture of gas and air from the mixing device to the burner. At least one of the feed channels runs from one end of the burner via at least one hollow chamber in the burner to the other end of the burner and extends in at least one component positioned near the burner to cool at least one section of the component facing the combustion chamber. The feed channel running through the hollow chamber in the burner is the third feed channel. The section facing the combustion chamber has a thin wall with good thermal conductivity. The component is a displacement body positioned on one end of the burner.

[0007] EP 3 431 872 A1 is directed to providing a cylindrical burner deck with reduced noise without a pressure drop and discloses a cylindrical premix gas burner comprising a cylindrical burner deck on the outside of which premix gas is combusted, a mixing chamber inside the cylindrical burner deck, an inlet for the introduction of premix gas in the mixing chamber, and an end cap delimiting the mixing chamber at the opposite side of the cylindrical burner from the inlet. The burner comprises a tube extending in the mixing chamber. The tube is at a first end attached to the end cap. The other end of the tube is open.

[0008] DE 19926871 A1 is directed to providing a mixing device for a gas burner with a simple structure and low pressure loss and discloses a gas burner for boiler having mixture unit comprising cylindrical sleeve filled with packing bodies arranged in flow path between gas nozzle and burner upper surface to form gas and air mixture. The burner has a combustion air channel connected to a fan, a gas nozzle, a mixture unit fitted after the gas nozzle and a cylindrical burner upper surface. The mixture unit comprises a cylindrical sleeve filled with packing bodies and is arranged in the flow path between the gas nozzle and the burner upper surface. The sleeve is preferably made of perforated metal sheet, a grating structure or a fibrous material.

[0009] The documents that are discussed above disclose devices, systems and methods that have an explosive risk when hydrogen is used as fuel gas.

[0010] The object of the invention is therefore to provide a device that has a low explosive risk even if hydrogen is used as fuel gas.

[0011] The object is solved by a volume reducer for a gas boiler, in particular a hydrogen boiler, placeable inside a burner chamber of a burner, the volume reducer comprising:

> a wall that protrudes into the burner chamber when the volume reducer is placed in the burner,
> wherein the wall is configured such that a gas mixture flowing into the burner is prevented from passing through the wall protruding in the burner chamber.

[0012] An advantage of the volume reducer is that it is easy to implement and that it reduces the amount of potentially explosive gas and air mixture inside the burner, thereby reducing possible damages during the explosion. Also, the volume reducer placed inside the burner chamber enhances the stability of flames on the burner deck and determines an even temperature distribution over the burner deck. In particular, the volume reducer improves the homogeneity of the flow speed of the mixture, thereby reducing the risk of flashback. Thus, hydrogen can be used as a fuel gas without having a high explosive risk.

[0013] This volume reducer is particularly useful for hydrogen boilers. A hydrogen boiler is a boiler to which fuel gas is supplied that comprises at least 90 mol% hydrogen. In fact, using a gas with high concentration of hydrogen as fuel gas strongly increases the risk of an explosion as well as of flashback.

[0014] It is noted that the volume reducer has a closed surface, meaning that wall of the volume reducer protruding inside the burner chamber represents a sort of barrier for the gas mixture flowing insider the chamber. In other words, the protruding wall is devoid of any opening or aperture so that the gas mixture cannot pass through the wall and is forced to deviate its flowing path and to circulate in a smaller space inside the burner chamber before being combusted at the burner ports. In this way, the amount of potentially explosive gas and air mixture inside the burner is reduced. Consequently, the damages due to a possible explosion is also reduced.

[0015] Another advantage of the volume reducer placed inside the burner chamber is a reduction in thermoacoustic noise and peak pressure of the flashback, in particular without reduction in pressure drop. As the pressure drop can basically remain unchanged, the same load can be reached with the same fan speed, i.e. without additional fan power.

[0016] In one example, the volume reducer is fixable to a peripheral wall of the burner, wherein the peripheral wall limits the burner chamber. Advantageously, the volume reducer is fixable to a wall of the burner chamber without the burner ports. For example, the volume reducer can be fixable to a wall orthogonal to the surface of the burner chamber comprising the ports and the volume reducer can extend longitudinally almost parallel to said surface with the burner ports.

[0017] In another example, the volume reducer comprises a fixing portion, in particular having an open end cap, said fixing portion being fixable at a peripheral wall of the burner chamber. The cap can have a cone shape. The fixing portion is used to fix the volume reducer to the burner chamber and does not protrude inside the chamber. The fixing portion can be represented for example by a flange structure connectable to the edges of a peripheral wall of the chamber such that once the volume reducer is fixed, the peripheral wall is completely closed by the wall of the volume reducer. The fixing portion can also be represented by a closed surface that can be fixed flush with the peripheral wall of the chamber.

[0018] In a further example, the volume reducer has an axisymmetric shape, in particular the shape of a truncated cone. In other words, the volume reducer can exhibits a symmetry around an axis, such as a cylinder, a cone, a trumpet shaped structure, etc.. Advantageously, the symmetry axis is parallel to the surface of the burner chamber having the burner ports. Other types of symmetric shapes can be considered for the volume reducer, such as mirror-symmetric, repetitive-symmetric or cyclic-symmetric shapes.

[0019] Also, the volume reducer can have a hollow body or a solid body, in particular filled with an insulating material. In case of a hollow body, the entire mass of the burner chamber is not extremely enhanced. The wall of the volume reducer can be shaped for example as a truncated cone and can be fixed to a peripheral wall of the burner chamber such that the wall of the volume reducer can represent a continuation of said peripheral wall protruding inside the chamber. In case of a solid body, the volume reducer can be filled with a suitable insulating material to avoid that the volume reducer becomes a heat sink during the combustion process.

[0020] The volume reducer is preferably realized by a single element. However, it can also be constituted by multiple elements for example placed in the middle of the burner chamber, such as glass or ceramic glass beads, or other forms of packing material made of heat resistant materials.

[0021] The volume reducer can be made of stainless steel (e.g. plates) welded or deep pressed. Alternatively, the volume reducer can be made of thermal insulating or ceramic material. The volume reducer can also be made of a combination of stainless steel plates filled with thermal isolation / ceramic material. In one example, the volume reducer can consist of stainless steel (e.g. plates) with an cap/back plate or can consist of stainless steel (e.g. plates) with an end cap/back plate of isolation/ceramic material.

[0022] In one example, the volume reducer can be swirl-shaped. This can improve the mixing of the gas flow inside the burner chamber despite the reduced space where the gas mixture is forced to flow.

[0023] It is noted that the volume reducer can preferably be used for gas boilers having a cylindrical burner. However, the volume reducer can advantageously be used also for gas boilers having flat burners, thereby creating a dead volume inside a mixing chamber of the burner and/or between the burner and a burner door. The volume reducer can be part of a burner door. The burner door is a component which closes an opening of a burner or mixing chamber.

[0024] According to another aspect of the invention, a burner for a gas boiler, in particular a hydrogen boiler is provided. The burner comprises a burner chamber for receiving a gas mixture and the inventive volume reducer placeable inside the burner chamber for reducing the space where a gas mixture flows inside said burner chamber.

[0025] Also, the burner chamber can comprise an end cap region and the volume reducer can be fixable at said end cap region. In this way, the end cap of the burner can be advantageously replaced by the volume reducer that acts at the same time as a cap element for the burner and as an element for reducing the space (i.e. the volume) inside the burner chamber.

[0026] According to an additional example, the volume ratio between the volume reducer and the burner chamber is comprised between 0.45 and 0.6, in particular between 0.50 and 0.58. Also, the volume of the burner chamber when the volume reducer is placed in the burner chamber is at least between 0.40 and 0.60 of the volume of the burner chamber without the volume reducer. For example, in a burner chamber of 0.9 liters, a volume reducer of about 0.52 liters can be used. In this case, the space (i.e. the volume) of the chamber with the volume reducer placed therein is about 0.42 times smaller than the space of the chamber without the volume reducer. In another example, in a burner chamber of 0.9 liters, a volume reducer of about 0.45 liters can be used. In this case, the space (i.e. the volume) of the chamber with the volume reducer placed therein is about 0.5 times smaller than the space of the chamber without the volume reducer.

[0027] In an additional example, the volume reducer has the shape of a truncated cone with a first base fixable to a peripheral wall of the burner chamber, a second base opposite to the first base and having a surface area smaller that the surface area of the first base, and a longitudinal surface extending from the first base to the second base. Advantageously, the second base faces the entrance at the manifold of the gas mixture.

[0028] The burner chamber can comprise a port region having a plurality of burner ports defining a perforation area of the burner chamber and a portion of the wall of the volume reducer can define an intermediate gap with said port region. In this case, it is obtained an equal distribution of the gas mixture over the burner ports, thereby reducing the risk of flashback.

[0029] In particular, the longitudinal surface corresponds to the portion of the wall of the volume reducer defining the intermediate gap, wherein said intermediate gap tightens passing from the second base to the first base. In case of a volume reducer having a cylindrical shape, the intermediate gap remains basically constant.

[0030] In one example, the transversal cross section of the intermediate gap at a determined distance from a peripheral wall of the burner chamber defines an inflow area at that distance, said inflow area being greater than the corresponding perforation area of the port region at said distance. It is noted that the port opening area, or perforation area, represents a parameter in relation with the perforation size of the burner ports. This configuration further increases equal distribution of the gas mixture over the burner ports.

[0031] According to an additional aspect of the invention, a combustion appliance, in particular a hydrogen boiler, comprising an inventive volume reducer or an inventive burner is provided. Examples of combustion appliances can include furnaces, water heaters, boilers, direct/in-direct make-up air heaters, power/jet burners and any other residential, commercial or industrial combustion appliance. In many cases, a combustion appliance can be modulated over a plurality of burner loads, with each burner load requiring a different flow rate of fuel resulting in a different heat output. At higher burner loads, more fuel and more air are typically provided to the burner, and at lower burner loads less fuel and less air are typically provided to the burner.

[0032] In a further aspect of the invention, a use of at least an inventive volume reducer or of an inventive burner for reducing the space where a gas mixture flows inside a burner chamber is provided.

[0033] In another aspect of the invention, a method for retrofitting a combustion appliance, in particular a hydrogen boiler is provided. The method comprises placing at least an inventive volume reducer inside a burner chamber of the combustion appliance, or installing an inventive burner according in the combustion appliance. In this way, it is possible to modify an already installed combustion appliance, such as a hydrogen boiler, by placing the volume reducer inside the burner chamber as mentioned above. For example, the volume reducer can be fixed to a peripheral wall of the burner or can advantageously replace the end cap of the burner. Alternatively, the combustion appliance can be modified by replacing the burner with a modified burner having a volume reduced placed inside.

[0034] In the figures, the subject-matter of the invention is schematically shown, wherein identical or similarly acting elements are usually provided with the same reference signs.

Figures 1A-C	show a schematic representation of a volume reducer and of a burner comprising the volume reducer according to examples.
Figure 2	shows a schematic representation of a burner comprising the volume reducer and the direction of the gas flow inside the burner chamber according to an example.
Figures 3A-B	show a schematic representation of a burner including a volume reducer with a shape of a truncated cone and a cross section of said burner according to an example.
Figures 4A-B	show a schematic representation of the inflow area in the burner chamber according to an example.
Figures 5A-E	show schematic representations of the burner chamber according to several examples.
Figure 6	shows a schematic representation of the of the burner chamber comprising a volume reducer according to a further example.
Figure 7	shows a schematic representation of a combustion appliance comprising a burner with a volume reducer according to an example.
Figures 8A-B	show a schematic representation and sections of the volume reducer having the shape of a truncated cone according to an example.
Figures 9A-B	show a schematic representation and sections of the volume reducer having the shape of a cylinder according to an example.

[0035] With reference to Figure 1A, a volume reducer 1 is shown. The volume reducer 1 exhibits a symmetry around a symmetry axis 11. In particular, the volume reducer 1 has the shape of a truncated cone. The volume reducer 1 has a wall 6 defining an external surface. In this case, the wall 6 is represented by the bases and the longitudinal lateral surface of the truncated cone structure.

[0036] Figures 1B and 1C schematically illustrate the placement of the volume reducer 1 inside the chamber 3 of a burner 4. These two figures show two different configurations of the volume reducer 1, wherein in both cases the volume reducer is fixed to a peripheral wall 8 of the chamber 3, i.e. to an internal wall 8 of the chamber 3, through a fixing portion 5.

[0037] In one case (Fig. 1B), the volume reducer 1 can be a solid element filled with a material (identical or different from the material of the wall) and the fixing portion 5 is represented by a surface flush with the peripheral wall 8 of the chamber 3. In another case (Fig. 1C), the volume reducer 1 can be a hollow element and the fixing portion 5 is represented by a ring or flange element connected to the peripheral wall 8 of the chamber 3. In addition, Figure 1C shows the example where the peripheral wall 8 of the chamber 3 is provided with an opening 27 and the volume reducer 1 is fixed at this opening 27, i.e. the fixing portion 5 is fixed to the edges of the opening 27, for example through a snap-fit mechanism. In this way, the volume reducer 1 works as a cap of the opening 27 and protrudes inside the chamber 27.

[0038] It is noted that also the peripheral wall 8 shown in figure 1B can be provided with an identical opening, wherein the fixing portion 5 completely covers said opening. In both cases of figures 1B and 1C, the wall 6 of the volume reducer 1 protrudes inside the chamber 3 and causes the space (i.e. the volume) inside the chamber 3 to be reduced. This is possible because the wall 6 of the volume reducer 1 is a closed surface, i.e. without any sort of perforation or opening through which the gas mixtures of the chamber 3 can pass through the volume reducer 1. Taking figure 1C as a reference, the wall 6 is a continued surface starting from an end of the fixing portion 5 to another end of said fixing portion 5. This particularly means that a gas mixture 15 flowing inside the chamber 3 is prevented from passing through the wall 6 of the volume reducer 1. This aspect is better illustrated in figure 2.

[0039] Figure 2 shows a section of burner 4 including inside a volume reducer 1. The burner 4 has a cylindrical shape and the volume reducer 1 has the shape of a truncated cone. The burner 4 comprises a port region 9 provided with a plurality of burner ports 10 (i.e. openings) distributed on the longitudinal surface of the cylindrical structure for the combustion of the gas mixture 15. The several ports 10 define a perforation area 21. Usually, the gas mixture 15 enters from a burner aperture 28, flows inside the chamber 3 of the burner 4 and exits from the ports 10 for the combustion. As shown in the figure, the presence of the volume reducer 10 prevents the gas mixture 15 from freely flowing inside the chamber 3. The nature of the wall 6 of the volume reducer 1, i.e. the fact that the wall 6 is a closed surface, reduces the free space inside the chamber 3 and the gas mixture 15 is forced to flow in the region between the volume reducer 1 and the port region 9 before exiting from the ports 10.

[0040] The region between the volume reducer 1 and the port region 9 or intermediate gap 16 is highlighted in figure 3A (shadowed area). The intermediate gap 16 is defined by the port region 9 of the burner 4 and a portion 22 of the wall 6 of the volume reducer 1. This figure shows an example of a burner 4 and of a volume reducer 1 placed in the chamber 3 of the burner 4. The burner 4 has a cylindrical shape having a base with a diameter Dc and a length L_B. The volume reducer 1 has a shape of truncated cone with a first base 13, a second base 14 and a longitudinal surface 29 connecting the first base 13 to the second base 14, wherein the first base 13, fixed to a peripheral wall 8 of the chamber 3 of the burner 4 is larger than the second base 14. It is noted that the longitudinal surface 29 corresponds to the portion 22 of the wall 6 of the volume reducer 1 defining the intermediate gap 16. The length of the intermediate gap 16 basically corresponds to the height Hr of the volume reducer 1, i.e. the distance between the first base 13 and the second base 14, i.e. the distance between the second base 14 from the peripheral wall 8 to which the volume reducer 1 is fixed.

[0041] It is noted that the aperture diameter Dc of the burner 4 is usually the same even for different burner outputs. The burner outputs can be in a range 20 to 50 kW , whereas the length L_B can vary based on these outputs.

[0042] Figure 3B is a cross section of figure 3A along the line A-A. The cross section is carried out at a distance d from the first base 13. At distance d, the volume reducer 1 has an average diameter Dr and the width of the intermediate gap is Wv. The area of the ring formed by subtracting the cross section area of the volume reducer 1 with a diameter Dr from the cross section area of the burner chamber 3 with a diameter Dc, represents a so called inflow area 12, that is the area crossed by the gas mixture 15 in the intermediate gap 16 before exiting the burner ports 10. In particular, if the perforation area 21 of the port region 9 is taken into account, the inflow area 12 at a certain distance from the peripheral wall 8 to which the volume reducer 1 is fixed, is always greater than the perforation area 21 at that distance. The relation between the perforation area 21 and the inflow area 12 is illustrated in figures 4A and 4B. In figure 4A, the variation of the inflow area 12 as a function of the distance from the first base 13 of the volume reducer 1 is shown. From figure 4B, it is clear that the inflow area 12i at a generic distance *i* is represented by the surface of a ring, whereas the perforation area 21_i is represented by the depth of said ring.

[0043] Figure 5A is an illustration of a burner 4 without the volume reducer 1 placed inside. The burner 4 has a chamber 3 connected to a manifold element 20 through a bend region 19. Figures 5B to 5E show four different examples of volume reducers 1 placed in the chamber 3 to reduce the volume of said chamber 3. As regards figure 5B, the volume reducer 1 has the shape of a hollow truncated cone and is fixed to a peripheral wall of the chamber 3 opposite to the manifold 20. In particular, the volume reducer 1 is located at an end cap region 18 of the burner 4. In this case, the volume reducer 1 replaces the end cap of the burner 4 and protrudes inside the chamber 3.

[0044] In figure 5C, the volume reducer 1 has the shape of a solid truncated cone and is fixed to a peripheral wall of the chamber 3 opposite to the manifold 20. In this case, the volume reducer 1 is not hollow and is filled with an insulating material. In figure 5D, the volume reducer 1 has the shape of a long trumpet. In this way, the space inside the chamber is further reduced due to the presence of a portion of the volume reducer 1 extending also in mixing area/manifold/bend region. It is noted that in both the configurations shown in figures 5C-5D the volume reducer 1 can replace the end cap of the burner 4, thereby protruding inside the chamber 3 from the end cap region 18. Figure 5E shows a different configuration, wherein the volume reducer 1 is fixed at a side of the manifold 20 or bend region 19. In this case, the volume reducer 1 has a cylindrical shape.

[0045] Figure 6 shows a burner 4 with a volume reducer 1 in the chamber 3 according to an example. In this case, the volume reducer 1 has the shape of a truncated cone and is fixed to the burner 4 at two different points. In particular, at one side the volume reducer 1 is held in place with a fixing rod 26, i.e. a threated rod, mounted on the bend region 19 of the manifold 20. The rod 26 is fixed through the employment of a suitable bolt 17. At the other side, the volume reducer 1 is connected to the peripheral wall 8 of the chamber 3 at the end cap region 18 of the burner 4. At the end cap region 18, between the volume reducer 1 and the end-cap of the burner 4, can be placed a graphite seal. It is noted that this configuration as well as the configuration of figure 5E, wherein the volume reducer 1 is directly or indirectly fixed to the bend region 19 of the manifold 20, can be advantageously used for experimental purposes to evaluate the efficient introduction of a such volume reducer 1 inside chamber 3.

[0046] Figure 7 illustrates a combustion appliance 7, i.e. a gas boiler 2, comprising the volume reducer 1 as described above. In particular, the combustion appliance 7 comprises an air inlet and gas inlet, wherein a gas mixture is formed and led to a gas burner 4 through a manifold 20. Inside the chamber 3 of the burner 4 is placed a volume reducer 1 having for example the shape of a truncated cone. The volume reducer 1 determined a reduction of the internal space of the chamber 3 so that the gas mixture is forced to flow in a reduced volume. Accordingly, damages arising from a possible explosion can be strongly reduced.

[0047] Figures 8A-8B and 9A-9B illustrate the volume reducer 1 according to two different configurations. Figure 8A shows for example a volume reducer 1 having the form of a truncated cone. The volume reducer 1 is solid, for example made of wood. The reducer 1 can be glued with silicon to the center of the burner end-cap, and clamped with a metal plate between burner flange and burner door. For this purpose, a plurality of fixing holes 24, for example three, are present on one base (i.e. first base or larger base) of the volume reducer 1. As shown in the lateral and transversal cross sections of the volume reducer 1 (Fig. 8B), for each fixing hole 24 a fixing channel 25 is provided. Each channel can have a length Lc comprised between 48 mm and 51 mm, in particular 49.8 mm, wherein each hole can have a diameter Dh comprised between 2 mm and 4 mm, in particular 3.2 mm. In addition, the volume reducer 1 can comprise a first base having a diameter Dr_1 comprised between 75 mm and 95 mm, in particular 88 mm, a second base having a diameter Dr_2 comprised between 65 mm and 75 mm, in particular 70 mm, and a length Hr comprised between 100 mm and 115 mm, in particular 107 mm.

[0048] Figure 9A shows for example a volume reducer 1 having the form of a truncated cone with a tapered frontal region 23. The volume reducer 1 is solid, for example made of aluminum. The volume reducer 1 is held in place through a fixing rod 26, as described in figure 6. For this purpose, one base (smaller base) of the volume reducer 1 is provided with a central fixing hole 24. As shown in the lateral and transversal cross sections of the volume reducer 1 (Fig. 9B), the reducer 1 is provided with a fixing channel 25. The fixing hole 24 has a diameter Dh comprised between 4 mm and 6 mm, in particular 5 mm and the channel 25 has a length Lc_1 comprised between 65 mm and 75 mm, in particular 70 mm. The channel further comprises a reinforced region having a length comprised between 45 mm and 55 mm, in particular 50 mm. The volume reducer 1 has a total height Hr_1 comprised between 100 mm and 115 mm, in particular 107 mm, and an intermediate height Hr_2 (from the larger base opposite to the smaller base provided with the fixing hole 24) comprised between 90 mm and 105 mm, in particular 97 mm. Due to the presence of the tapered region 23, the volume reducer 1 comprises a larger base having a diameter Dr_1 comprised between 70 mm and 90 mm, in particular 80 mm, an intermediate base having a diameter Dr_2 comprised between 65 mm and 75 mm, in particular 70.9 mm, and a smaller base having a diameter Dr_3 comprised between 45 mm and 55 mm, in particular 50 mm.

Reference Signs

[0049]

1. Volume reducer
2. Gas boiler
3. Burner chamber
4. Burner
5. Fixing portion
6. Wall
7. Combustion appliance
8. Peripheral wall
9. Port region
10. Burner ports
11. Symmetry axis
12. Inflow area
13. First base
14. Second base
15. Gas mixture
16. Intermediate gap
17. Bolt
18. End cap region
19. Bend region
20. Manifold
21. Perforation area
22. Portion of wall
23. Tapered region
24. Fixing holes
25. Fixing channel
26. Fixing rod
27. Opening
28. Burner aperture
29. Longitudinal surface

Claims

1. Volume reducer (1) for a gas boiler (2), in particular a hydrogen boiler, placeable inside a burner chamber (3) of a burner (4), the volume reducer (1) comprising:
   a wall (6) that protrudes into the burner chamber (3) when the volume reducer (1) is placed in the burner (4), wherein the wall (6) is configured such that a gas mixture (15) flowing into the burner (4) is prevented from passing through the wall (6) protruding into the burner chamber (6).

2. Volume reducer (1) according to claim 1, **characterized in that** the volume reducer (1) is fixable to a peripheral wall (8) of the burner (4), wherein the peripheral wall (8) limits the burner chamber (3).

3. Volume reducer (1) according to any one of claims 1 to 2, **characterized in that** the volume reducer (1) comprises a fixing portion (5), in particular having an cap, said fixing portion (5) being fixable at a peripheral wall (8) of the burner chamber.

4. Volume reducer (1) according to any one of claims 1 to 3, **characterized in that**

   a. the volume reducer (1) has an axisymmetric shape, in particular the shape of a truncated cone; and/or
   b. the volume reducer (1) has a hollow body or a solid body, in particular filled with an insulating material.

5. Volume reducer (1) according to any one of claims 1 to 3, **characterized in that** the volume reducer (1) is swirl-shaped.

6. Burner (4) for a gas boiler (2), in particular a hydrogen boiler, comprising:

a burner chamber (3) for receiving a gas mixture (15), and
at least a volume reducer (1) according to any one of claims 1 to 5, placeable inside the burner chamber (3) for reducing a space where a gas mixture (15) flows inside said burner chamber (3).

7. Burner (4) according to claim 6, **characterized in that** the burner chamber (3) comprises an end cap region (18) and the volume reducer (1) is fixable at said end cap region (18).

8. Burner (4) according to any one of claims 6 to 7, **characterized in that**

a. the volume ratio between the volume reducer (1) and the burner chamber (3) is comprised between 0.45 and 0.6, in particular between 0.50 and 0.58; and/or
b. the volume of the burner chamber (3) when the volume reducer (1) is placed in the burner chamber (3) is at least between 0.40 and 0.60 of the volume of the burner chamber (3) without the volume reducer (1).

9. Burner (4) according to any one of the claims 6 to 8, **characterized in that** the volume reducer (1) has the shape of a truncated cone with a first base (13) fixable to a peripheral wall (8) of the burner chamber (3), a second base (14) opposite to the first base (13) and having a surface area smaller that the surface area of the first base (13), and a longitudinal surface (29) extending from the first base (13) to the second base (14).

10. Burner (4) according to any one of the claims 6 to 9, **characterized in that** the burner chamber (3) comprises a port region (9) having a plurality of burner ports (10) defining a perforation area (21) of the burner chamber (3) and a portion (22) of the wall (6) of the volume reducer (1) defines an intermediate gap (16) with said port region (9).

11. Burner (4) according to claims 9 and 10, **characterized in that** the longitudinal surface (29) corresponds to the portion (22) of the wall (6) of the volume reducer (1) defining the intermediate gap (16), wherein said intermediate gap (16) tightens passing from the second base (14) to the first base (13).

12. Burner (4) according to any one of claims 10 to 11, **characterized in that** the transversal cross section of the intermediate gap (16) at a determined distance from a peripheral wall (8) of the burner chamber (3) defines an inflow area (12) at that distance, said inflow area (12) being greater than the corresponding perforation area (21) of the port region (9) at said distance.

13. Combustion appliance (7), in particular a hydrogen boiler, comprising the volume reducer (1) according to any one of claims 1 to 5 or the burner (4) according to any one of clams 6 to 12.

14. Use of at least a volume reducer (1) according to any one of claims 1 to 5 or of at least a burner (4) according to any one of claims 6 to 12 for reducing the space where a gas mixture (15) flows inside a burner chamber (3).

15. Method for retrofitting a combustion appliance (7), in particular a hydrogen boiler, comprising
placing at least a volume reducer (1) according to anyone of claims 1 to 5 inside a burner chamber (3) of the combustion appliance (7), or
installing a burner (4) according to any one of claims 6 to 12 in the combustion appliance (7).

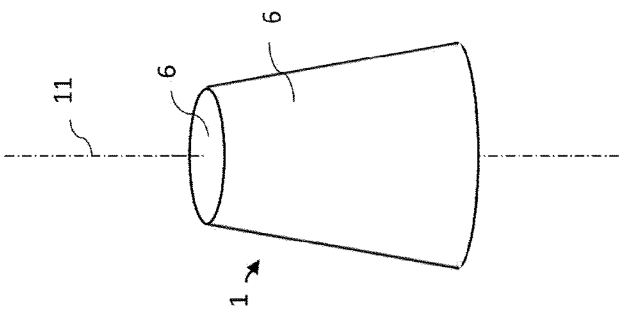

Fig. 1A

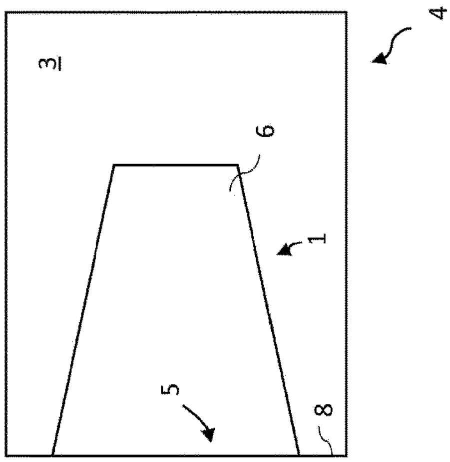

Fig. 1B

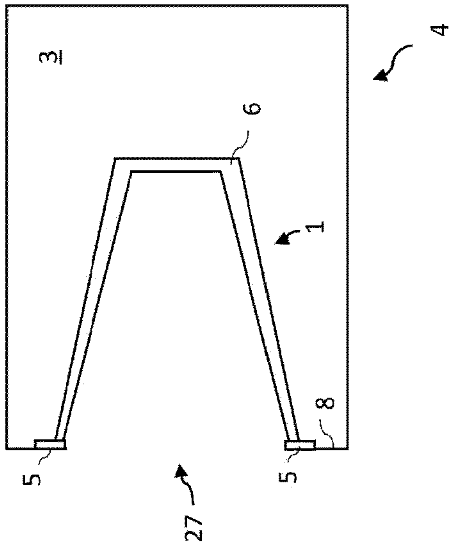

Fig. 1C

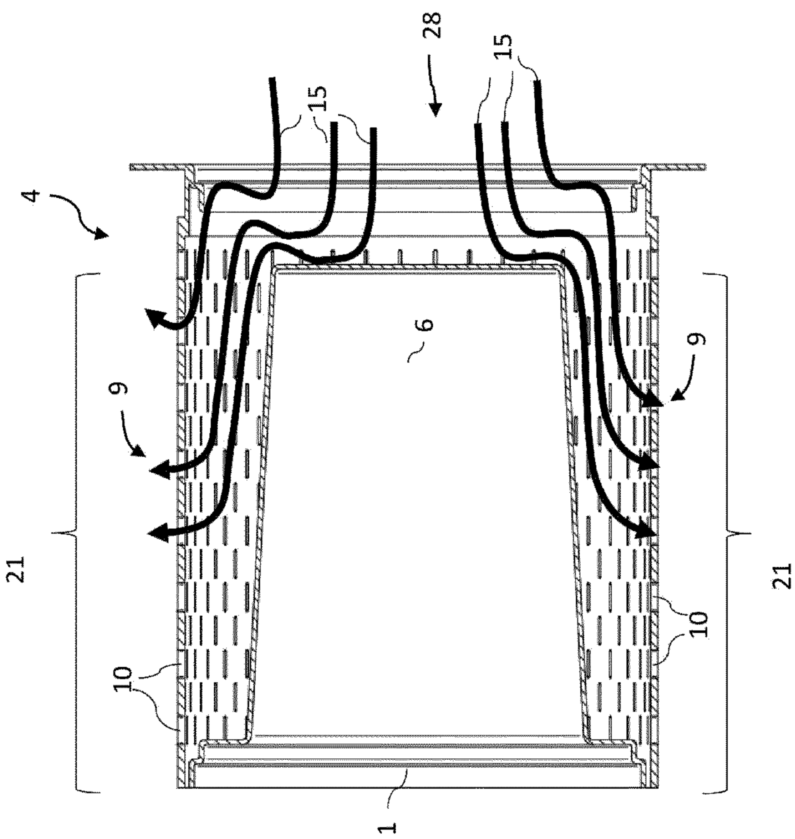

Fig. 2

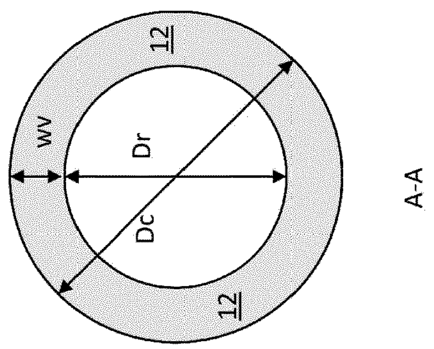

Fig. 3B

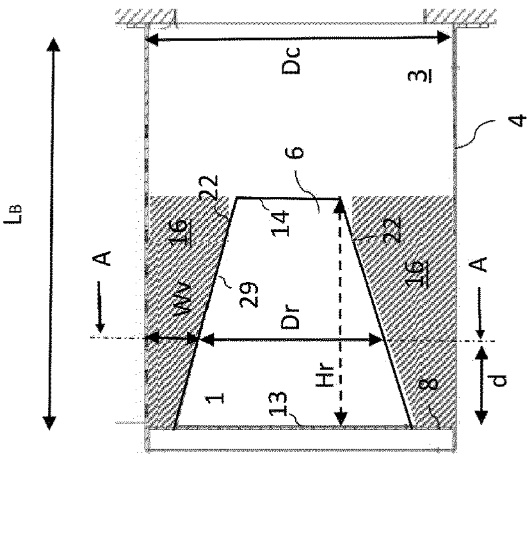

Fig. 3A

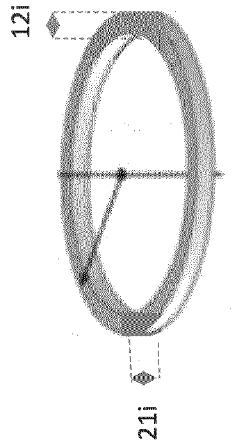

Fig. 4B

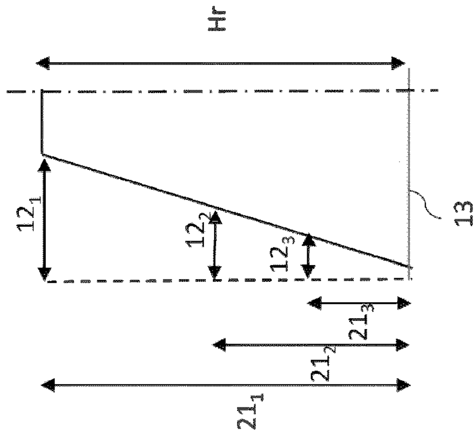

Fig. 4A

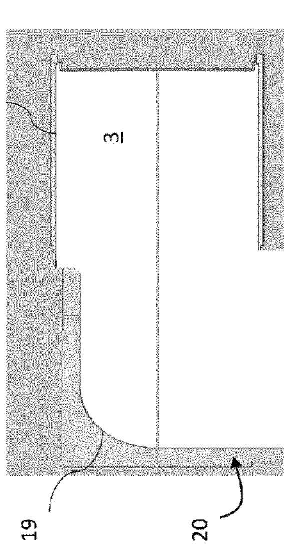

Fig. 5A

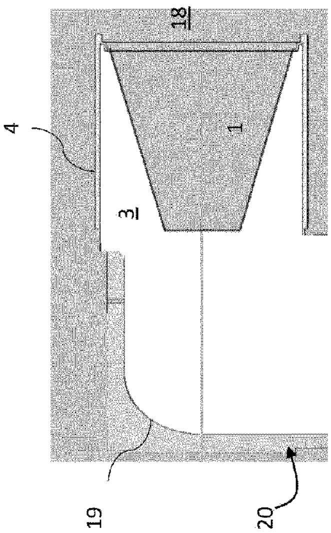

Fig. 5B

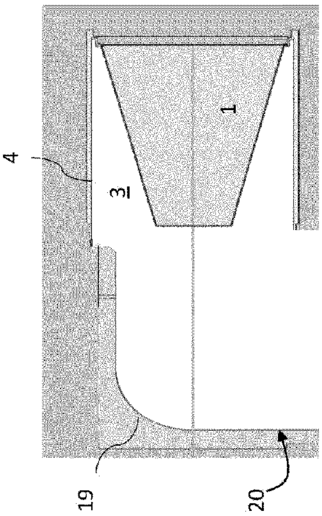

Fig. 5C

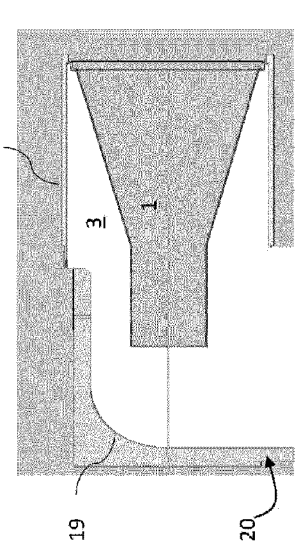

Fig. 5D

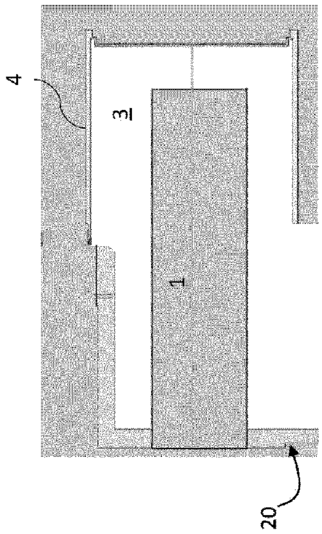

Fig. 5E

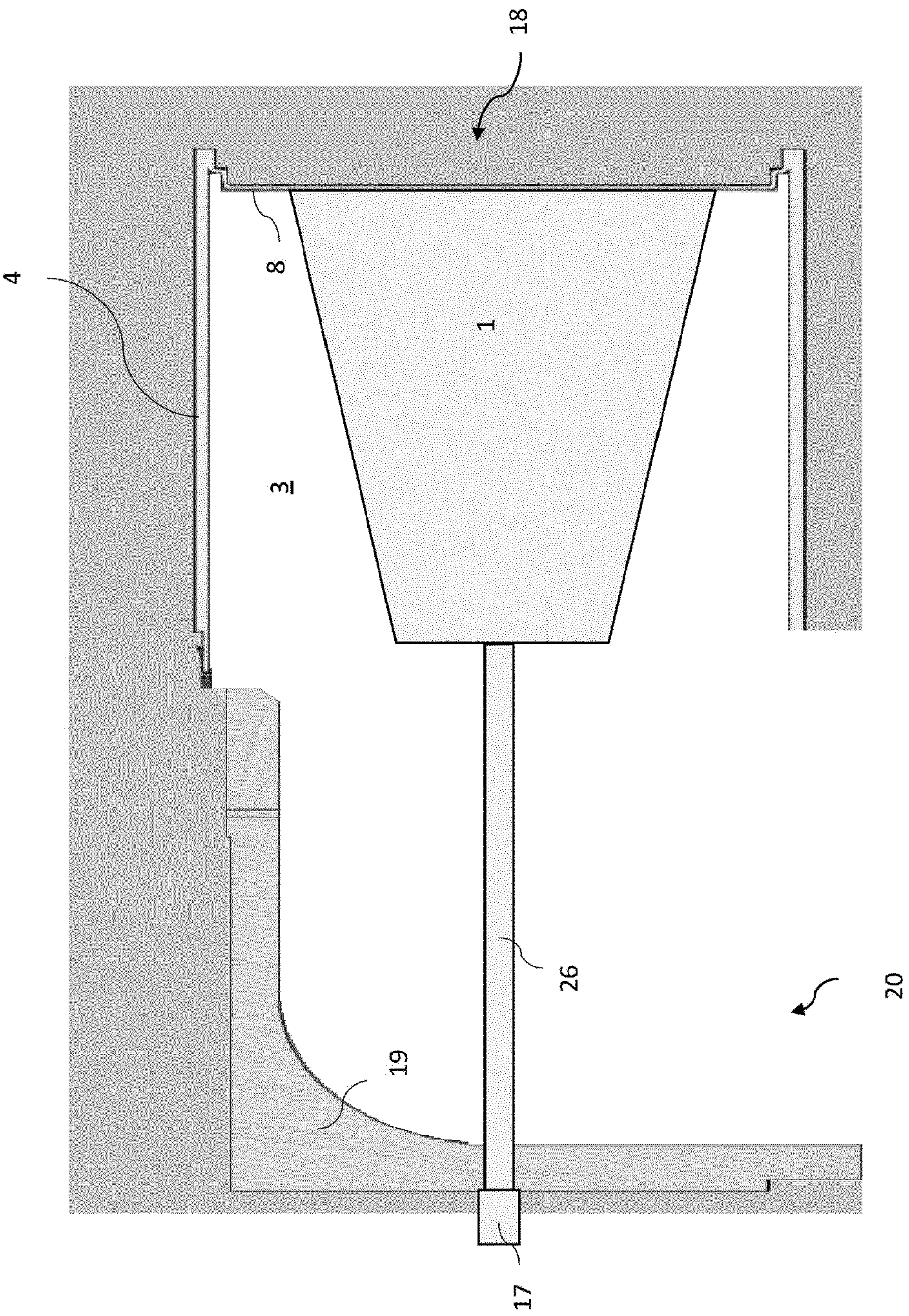

Fig. 6

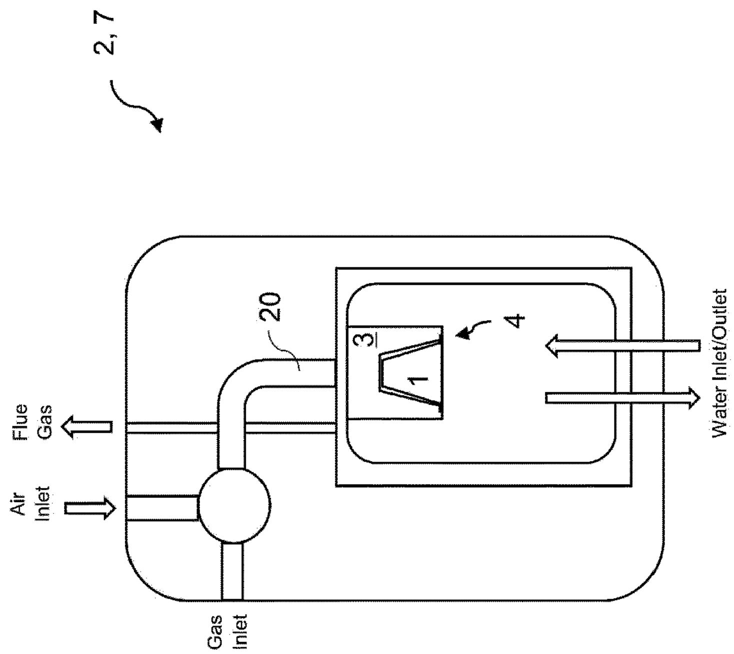

Fig. 7

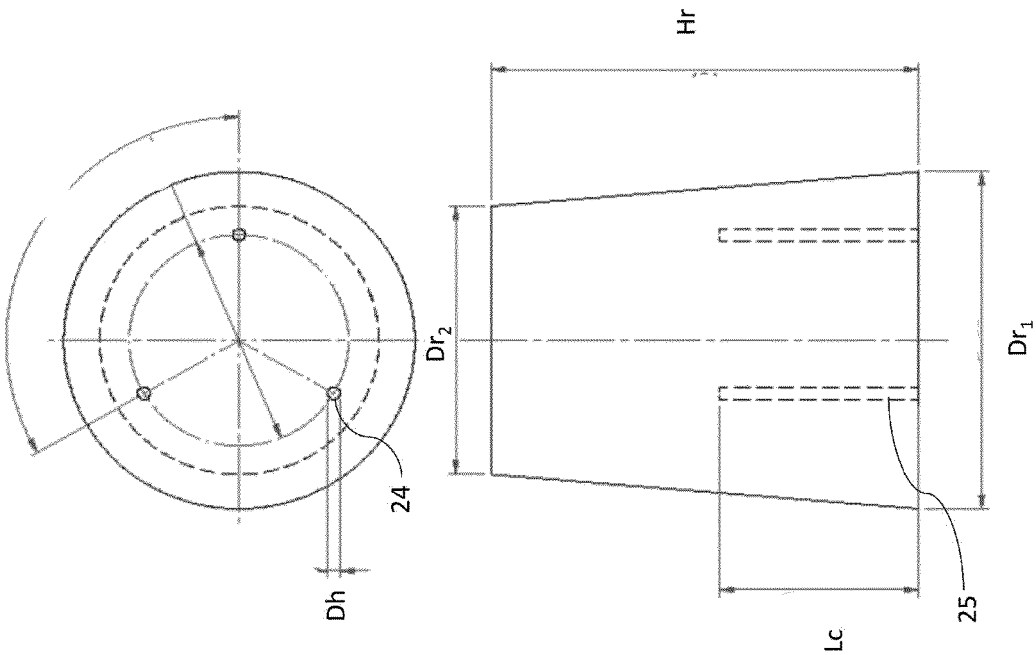

Fig. 8B

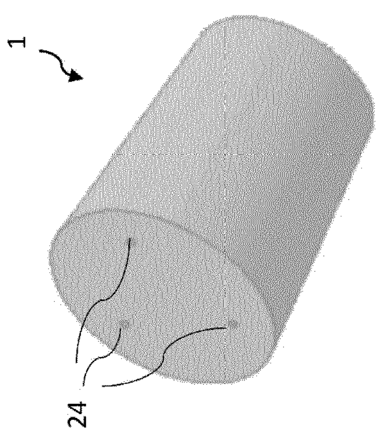

Fig. 8A

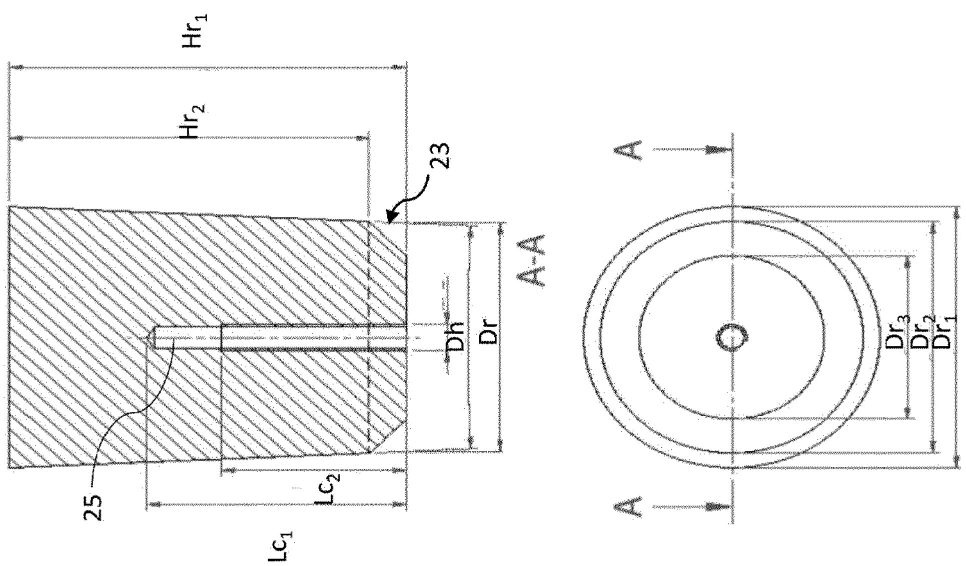

Fig. 9B

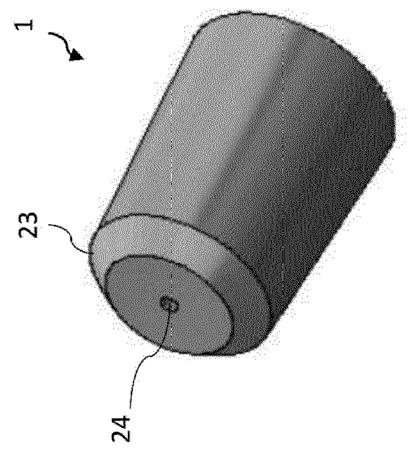

Fig. 9A

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 18 7117

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2016/356492 A1 (DEIVASIGAMANI SRIDHAR [US] ET AL) 8 December 2016 (2016-12-08) * paragraphs [0024], [0025], [0052], [0053] * * figures 2, 3 * -----	1-15	INV. F23D14/02 F23D14/70
X	GB 2 072 317 A (HAMWORTHY ENGINEERING) 30 September 1981 (1981-09-30) * page 1, lines 24-32, 70-72 * * figure 1 * -----	1-15	
X	EP 1 546 608 A2 (POWERTECH IND INC [CA]) 29 June 2005 (2005-06-29) * paragraphs [0020], [0024], [0027] * * figures 6A, 8A * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
F23D
F23C

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 January 2022	Vogl, Paul

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 18 7117

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-01-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016356492 A1	08-12-2016	NONE	
GB 2072317 A	30-09-1981	NONE	
EP 1546608 A2	29-06-2005	AU 2003273663 A1	23-04-2004
		CA 2500769 A1	15-04-2004
		CN 1720414 A	11-01-2006
		EP 1546608 A2	29-06-2005
		JP 4413141 B2	10-02-2010
		JP 2006501429 A	12-01-2006
		KR 20050071541 A	07-07-2005
		US 2007042300 A1	22-02-2007
		WO 2004031651 A2	15-04-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6139312 A **[0004]**
- US 20200049345 A1 **[0005]**
- EP 1221571 B1 **[0006]**
- EP 3431872 A1 **[0007]**
- DE 19926871 A1 **[0008]**